Building a Lidar network in Latin America: Progress and Difficulties.

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ABSTRACT

We describe recent, ongoing, and future efforts to create a lidar network in Latin America through the integration of existing lidar projects and the establishment of new ones. An important part of this effort is to build on existing capabilities and to train scientists at each of the new sites to be able to operate their own observatories. For that purpose regular Workshops on Lidar measurements in Latin America have been conducted every two years from 2001. Lidar researchers all over the world attended the three workshops already held. Several actions have been conducted to prepare the preliminary conditions for the future network. Despite the difficulties and limitations that the lidar community in Latin America confronts, we reaffirm our commitment for the future Lidar Network in Latin America. For such a goal we will maintain the regular workshops every two years. Finally we announce the IV Workshop on Lidar Measurements in Latin America, to be held in the summer of 2007 in Sao Paulo, Brazil.

1. INTRODUCTION

The implementation of a lidar network has been a common goal among the few lidar teams in Latin America during recent years. Coordinated efforts have been conducted for establishing regular scientific meetings in the region addressing the issue of lidar application for research. The creation of a lidar network in Latin America is seen as a process of integration of existing lidar projects and the establishment of new ones. An important part of this effort is to build on existing capabilities and to train scientists at each of the existing and prospective sites to be able to operate their own observatories. For that purpose regular Workshops on Lidar measurements in Latin America have been conducted every two years from 2001. Lidar researchers all over the world attended the three workshops already held. In that frame several efforts have been conducted for the establishment of a lidar network in Latin America. One and two wavelength low cost compact lidars have been designed, with the purpose of standardizing measurements. Preliminary quality control and processing protocols for lidar measurements have been drafted. Because the main limitation is the lack of funds, joint proposals have been submitted unsuccessfully to NASA and the IAI.

2. WORKSHOP SERIES

This effort became a reality in the year 2001 with the I Workshop held on 6 to 8 March, in Camagüey, Cuba, supported by the IAI Project PESCA 17 [1]. The original two goals were: to promote communication and cooperation between the members of the scientific community engaged in lidar research in Latin America as well as to plan future lidar research projects in the region. The II Workshop was held on February 17 to 21 of 2003, also in Camagüey, Cuba, supported by the IAI and ESA [2]. The two initial goals were complemented by a third one: to facilitate the education and scientific capacity building of the students/young scientists related to lidar research in Latin America. This goal was achieved hosting a pre-workshop course on lidar measurements, processing and analysis. The third one was held on 11 to 15 July 2005, in Popayan, Colombia, supported by ICTP, OSA and CLAF [3]. A series of conferences on lidar progresses were given during the first days for students and young scientists.

Because of the exchanges between scientists from Latin America and attendees from all over the world, a new lidar has been installed recently in the Laboratorio de Física de la Atmósfera, Universidad Mayor de San Andrés, La Paz, Bolivia. Also several exchange visits have been conducted and others have been planned. In addition several joint papers have been presented at international meetings as well as several joint proposals have been drafted and submitted to national and international funding agencies. In the last case was the proposal “The distribution and radiative impact of aerosols in the Americas”, submitted to the IAI CNR-II call, which unfortunately was not selected. All the lidar teams in Latin America joined in the drafting of such proposal. The following review of the existing and prospective lidar sites in Latin America is intended for calling the attention of the international lidar scientific community to the perspectives of establishing a lidar network in this region in the near future. Special emphasis is made in the main difficulties and limitations confronted by our lidar groups.

3. CURRENT LIDAR PROJECTS

Argentina:

The CEILAP (CITEFA-CONICET) Research Laboratory, located in Villa Martelli, Pcia. de Buenos Aires, began its lidar research in 1993. It is the facility with the greatest number of operative lidars: 5 at the present time. Currently measurements of tropospheric aerosols, ozone, cirrus clouds and water vapour are routinely conducted. Several of the senior and young researchers from this Lab have been trained in European lidar facilities. Also a CIMEL solar photometer of AERONET (NASA) is placed at the same site.

The Lab has been working in several cooperation research projects with France, Japan, Italy, Switzerland, Brazil and Cuba. A joint research project with the Cuban lidar team is evaluating the capabilities of the former UT aerosols measurements to be used also for deriving stratospheric aerosols properties. Campaign measurements supported by the Japan Cooperation International Agency, JICA, have been conducted in the south of Argentina recently.

The most recent development is the design and construction of a mobile laboratory with a multiwavelength lidar to study tropospheric aerosols, a differential absorption lidar for stratospheric ozone and water vapor Raman lidar. In the same place there are also several radiometric systems, and a second CIMEL solar photometer of AERONET (NASA). The experimental site is described in the Web site http://www.division-lidar.com.ar. These instruments are installed in Río Gallegos, Sta. Cruz, Argentina. The set of measurements conducted by these equipments showed the capabilities to obtain valuable measurements of atmospheric parameters in the South of the American Continent.

Brazil:

INPE, São José do Campos:

The INPE lidar, located at São José do Campos (23° S, 46° W), has been in existence since 1969. It is one of the very few stations holding long time record measurements of the sodium layer and stratospheric aerosols. Early measurements were made with a ruby laser at 694.3 nm, and from 1972 on the lidar has used a dye laser tuned to 589 nm. At the time of writing this paper a new laser, which produces 589 nm by mixing the emissions from two solid state IR lasers, is being installed [4]. The lidar uses a three-channel photon counting receiver with overlapping high sensitivity, low sensitivity and Raman channels [5]. The lidar uses a 75 cm receiving mirror and a 122 cm plane mirror makes it possible to steer the beam.

Although the main application of the INPE lidar has been for studying atmospheric sodium between 80 and 110 km, non-resonant scattering profiles are also obtained for heights between about 15 km and 70 km. This latter data has been used for studying the climatology of the stratosphere and lower thermosphere at 23° S, and the long-term behavior of the stratospheric aerosol [6]. The sodium measurements have led to the publication of around 60 papers over the past 30 years, and it is worth mentioning that the first ever measurement of a sporadic sodium layer was made by the INPE lidar in 1976 [7]. The sodium measurements have also been used for global change studies [8].

At the time of writing lidar data is obtained on about one day per week on average, and preparations are under way for measuring the Doppler temperature profile between about 80 and 100 km. The Web site is at: http://www.laser.inpe.br/fisat/english/index.htm

IPEN, São Paulo:

A ground-based elastic backscatter lidar system has been recently developed in the Laboratory of Environmental Laser Applications at the Centre for Laser and Applications (CLA) at the Instituto de Pesquisas Energéticas e Nucleares – IPEN, São Paulo (23° 33' S, 46° 44' W). The lidar system is a single-wavelength backscatter system pointing vertically to the zenith and operating in the coaxial mode.

The light source is based on a commercial Nd:YAG laser (Brilliant by Quantel SA) operating at the second harmonic frequency (SHF), namely at 532 nm, with a fixed repetition rate of 20 Hz. The average emitted power can be selected up to values as high as 3.3 W. The emitted laser pulses have a divergence of less than 0.5 mrad. A 30 cm diameter telescope (focal length f = 1.3 m) is used to collect the backscattered laser light. The telescope’s field of view (FOV) is variable (0.5-5 mrad) by using a small diaphragm. The lidar is currently used with a fixed FOV of the order of 1 mrad, which according to geometrical calculations permits a full overlap between the telescope FOV and the laser beam at heights higher than 300 m above the lidar system. This FOV value, in accordance with the detection electronics, permits the probing of the atmosphere up to the free troposphere (5-6 km asl.). A Raman channel is currently being added, and is foreseen for the near future an upgrade of the system. This will enable us to determine the aerosol extinction and the aerosol backscatter coefficients independently at 355 nm.

The backscattered laser radiation is then sent to a photomultiplier tube (PMT) coupled to a narrow band (1 nm FWHM) interference filter, to assure the reduction of the solar background during daytime operation and to improve the signal-to-noise ratio (SNR) at altitudes greater than 3 km. The PMT output signal is recorded by a dual acquisition analog and photon counting system. Data are averaged between 2 to 5 minutes and then summed up over a period of about one hour, with a typical spatial resolution of 15 m, which corresponds to a 100 ns temporal resolution. The lidar system is destined for measuring the planetary boundary layer height, aerosol optical thickness and aerosol extinction and backscattering aerosol coefficients

For guarantying the continuity and progress of this lidar team international cooperation is needed both with financial and capacity building resources.

Bolivia:

The atmospheric science group at Universidad Mayor de San Andres (UMSA), La Paz, Bolivia has been working on subjects related to ozone and UV since 1994. The group has expanded during this decade both in terms of technical capabilities as well as scientific expertise. As part of its strategy of increasing its research capabilities and in order to take advantage of its geographical location (15.5ºS, 68.1ºW, 3420 m asl) some researchers attended the I Workshop on Lidar Measurements in Latin America, held in Camagüey, Cuba, on March 2001. As a result of contacts established in the aforementioned workshop, the European Space Agency decided to donate an Alexandrite Lidar to UMSA. This Lidar has been refurbished in Torino by Quanta System and tested at the University of La Sapienza under the leadership of Prof. G. Fiocco. At the same time, collaboration between the Cuban and Bolivian groups has been taking place with positive results. The Cuban group has been transmitting its long experience with lidars to the Bolivian group.

Last year, a proposal was submitted to NASA to establish a Raman lidar at the Laboratory for Atmospheric Physics at La Paz with the goal of providing measurements of use to the Network for the Detection of Stratospheric Change (NSDC). The proposal was accepted but budget cuts at NASA have thus far prevented initiation of this activity. Given the short experience in the Lidar field, however, one of the most important requirements of the LPA is training of the scientific and technical personnel. This training effort is continuing with NASA through a recently executed grant with Howard University (HU) in Washington, DC. Through this grant, LAP personnel will be working with Dr. David Whiteman at NASA/GSFC and participating in two NASA-funded lidar field measurement campaigns.

Colombia:

Although there is no a lidar installed in Colombia several Universities have been working together for increase their infrastructure and capacity building in this area from the year 2002 approximately. They are the Universidad del Cauca, Universidad del Valle and the Pontificia Universidad Javeriana and actually the Universidad Nacional Sede Medellín. Both researchers and students have participated in the development and implementation of two tropospheric lidars. They also have worked in the assimilation of the know-how on tropospheric aerosols measurements with lidar. Several cooperation engagements are on course. Among them are personnel training and scientific exchanges on lidar matters with the Institute for Applied Physics, Italy; the Grupo de Optica Atmosferica, Universidad de Valladolid, Spain and the European Space Agency.

The Colombian researchers and professors hosted, very successfully, the Second Course on Lidar Measurements and the Third Workshop on Lidar Measurements in Latin America in Popayán, Cauca, Colombia, between 11 and 15 July 2005. Very successful and fruitful scientific exchanges took place during the Course and the Workshop, reaching the main goal of maintaining fluid exchanges and cooperation between the lidar communities in the region. Further research activities are under way. Several Colombian researchers are contributing as Co-investigators in the e-ARI ALOMAR Project as well as in the POLARCAT Project.

This group of researchers and professors need a strong support both in scientific exchanges and capacity building as well as with funds.

Cuba:

The lidar for stratospheric aerosols measurements was installed in Camagüey by the end of 1989. It was part of the scientific cooperation between Cuba and the former Soviet Union. The lidar operated between 1992 and 1997. Measurements were conducted almost the complete period that the Pinatubo stratospheric aerosol cloud remained in the tropics. Such dataset have been used in several studies; GCM simulations of Mt. Pinatubo effects on global climate [9]; altitude corrections in the aerosol optical depths retrieval from TOMS instrument [10], and lately as part of a global lidar network for validating SAGE II measurements from the Mt. Pinatubo eruption [11,12].

Because the lack of funds it have been impossible to finish refurbishing the Old Russian lidar, although several contributions with parts and components have made it possible to re-establish several of the lidar systems. In that situation the lidar team have been working on re-processing of stratospheric aerosols and cirrus clouds lidar measurements dataset as well as combining lidar and satellite UT/LS aerosols measurements. Also a research is being conducted evaluating the impact of stratospheric aerosols and cirrus clouds on radiative transfer in the Great Caribbean.

Cooperation has been established with the Bolivian lidar team, contributing to capacity building. Also a joint research project is underway with the Argentinean team for evaluating potential use of original designed tropospheric aerosol measurements for studying UT/LS. Prospects for future cooperation are being explored. The Web site for Camagüey Lidar is: http://www.camaguey.cu/uct/meteorologia/LIDAR.htm

4. SUMMARY

The lidar community in Latin America is characterized by a disparity in the current lidar operating systems. Also there are different levels of expertise and qualification among its research and engineer staffs. The current series of workshops and courses is aimed to help in capacity building and exchanges both among the region and with the rest of the international lidar community. Despite the difficulties and limitations we confront, we reaffirm our commitment for the future Lidar Network in Latin America. For such a goal we will maintain the regular workshops every two years. We call the lidar community all over the world to contribute to the development and progress of the lidar community in Latin America.

The lidar teams from Brazil will be hosting the IV Workshop on Lidar Measurements in Latin America, to be held in the summer of 2007 in São Paulo. Information about the Pre-Workshop course for young lidar researchers and students will be provided soon.

The homepage for the Workshop Series, with information about the former ones and the next IV Workshop in Brazil will announced and demonstrated.

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